

Femur Fracture CLIFF Peer Review

1. *Strength of evidence presented in CLIFF in modeling the characteristics and mission impact of this medical condition within the spaceflight environment?*

Score: 3

Grading Scale:

4 - *Confident*

3 - *Somewhat confident*

2 – *Neutral*

1 – *Somewhat unconfident*

0 – *Not confident*

2. How confident are you that these data accurately represent the spaceflight environment?	Tables 1, 2 Composite Incidence and Level of Confidence	Table 3, 4 BC/WC Loss of Crew and probability	Table 4 - Clinical Phase 1, 2 durations Table 5 – CP 2 Loss of Crew	Table 4 – RTDC % Table 6 – RTDC Loss of Crew	Table 4 – Loss of Crew Life % Table 7 – Loss of Crew Life, Loss of Crew	Table 8 – TI
Score	3	2	2	2	3	3

Comments and limitations:

1. General comments. The literature search involving femur fractures breaks the condition down into traumatic fractures and stress fractures. Among traumatic conditions, there is further subdivision between proximal (hip) and distal femur fractures. As on other CLIFFs, the risk of traumatic femur fractures during microgravity operations is assumed to be close to zero. However, femoral stress fractures can occur during daily exercise sessions that the astronauts perform as well as during surface EVA's. Traumatic fractures were considered to be a possibility only during lunar EVA's.

2. Incidence. Separate distribution functions were made for traumatic fractures during EVA operations and for stress fractures throughout the mission. Proximal femur fractures were calculated using a fracture risk model while distal fractures used terrestrial data. Through simulation, the two were combined to create a composite incidence proportion. Stress fractures were calculated using a paper that studied their risk during athletic training, which appears appropriate. The resulting distributions show a very low incidence for traumatic fractures and a somewhat higher risk for stress fractures, as expected. The best case/worst case probabilities,

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clinical phase durations, RTDC and Loss of crew life probabilities were difficult to assess given the paucity of data, particularly for the untreated cases. However, the assumptions that were made to support the assignment of values appears to be rational extrapolations of the available data. The probability density curves that were derived appear to be a reasonable representation of the data presented.

3. Clinical phase data. I am in agreement with the clinical phase 1 durations entered in this CLIFF. This data was compiled by a team of expert clinicians, and I was involved in the discussions leading to the calculation of the clinical phase durations. CP2 data for worst case scenarios was limited by the paucity of available studies.

4. Task impairment. The analysis was performed and reviewed by a separate team of expert clinicians. I am aware of the methods that were used but did not directly participate in the discussions.

5. Dependence on mission phase or duration of mission. This medical condition depends on the mission phase, specifically surface EVA's vs microgravity operations.

6. Limitations

- This condition covers multiple different fracture types in the femur. It includes both traumatic and stress fractures. This is a challenge for incidence, duration, RTDC, and Loss of crew life as these numbers vary by fracture type, particularly in regard to stress fractures, which can have a protracted treatment course.
- Treated worst-case Loss of crew life is likely an underestimate because literature assumes terrestrial standard of care treatment is available (i.e. surgery). Orthopedic surgery is not a medical capability planned for lunar exploration missions. For lunar missions, the short evacuation time to return to earth will help decrease Loss of crew life probability, but it is likely that this is an underestimate.
- There is a paucity of data for mortality associated with untreated best-case femoral fractures, thus the best-case treated Loss of crew life values were repeated for this scenario. This is a limitation of this CLIFF. This likely underestimates the best-case untreated Loss of crew life.
- The literature search was unable to identify any data regarding the duration or RTDC for untreated worst-case femur fractures, since terrestrial standard of care includes treatment. Thus, the treated worst-case duration and RTDC are used again in this scenario. This is a limitation of this CLIFF.
- This CLIFF will need to be expanded for IMPACT 2.0 to include Martian surface operations.

Reviewed by:

David C. Hilmers